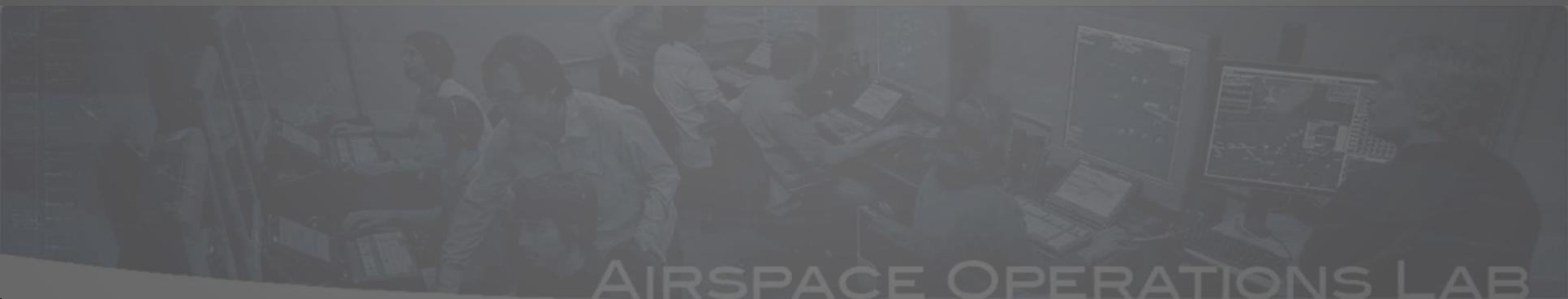




MACS Flight Deck Overview

Joey Mercer & Michael Kupfer



Outline

- Overview
- MACS Flight Deck Simulation Basics
- Flight Deck Capabilities
- Human-Automation Cooperation
- Other Flight Deck Options
- Pilot Workstation Configuration
- Troubleshooting

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MACS Flight Deck Overview

- MACS is a complete flight simulator
 - Originally started as an interface to PAS...
 - No “background” aircraft
 - All aircraft in MACS can be controlled by a human operators at any time
 - Can be configured as a pseudo pilot workstation designed around simulating/flying several aircraft
 - Can be configured as a single pilot workstation designed to better mimic the look and feel of a glass cockpit

MACS Flight Deck Overview

The screenshot displays the MACS (Multi-Access Cockpit System) interface for flight deck overview. The main window is titled "MACS CTRL 16 AC" and shows a list of aircraft under "Pilot Handoff NWA935". The aircraft list includes AAL204, AAL246, AAL337, AAL345, AAL440, AWE308, COA356, COA636, COA979, DAL283, NWA935, UAL188, UAL196, UAL273, UAL772, and UAL793. The interface is divided into several functional panels:

- MACS TO DO 4 AC:** A task list for the aircraft, showing items like COA979, UAL772, and AAL204 with their respective status and crew members.
- MACS CDU:** A keyboard interface for entering flight data, showing active routes and ATC messages.
- MACS Mode Control Panel:** Controls for speed (.78), heading (126), and altitude (33000). It includes options for speed selection (SPD SEL, VNAV, SPACING, MACH) and heading selection (HDG SEL, LNAV).
- MACS FMS Route Panel:** Displays the next waypoint (SPS) and provides controls for departure, star, and approach procedures, including options for climb to cruise alt and precision descend.
- MACS FMS VNAV Panel:** Shows vertical navigation parameters such as CRZ ALT (33000), CLB SPD (250), and CRZ SPD (.78).
- MACS Datalink Controls:** Buttons for ACCEPT, LOAD, and REJECT.
- MACS Datalink Display:** Shows datalink messages, such as "233106 OPEN CRZ ALT 310".
- MACS PFD:** A Primary Flight Display showing altitude (33000), speed (.78), and heading (120).
- Traffic Display:** A radar-like display showing the aircraft's position relative to other traffic, including UAL196, COA356, AWE308, and UAL793.

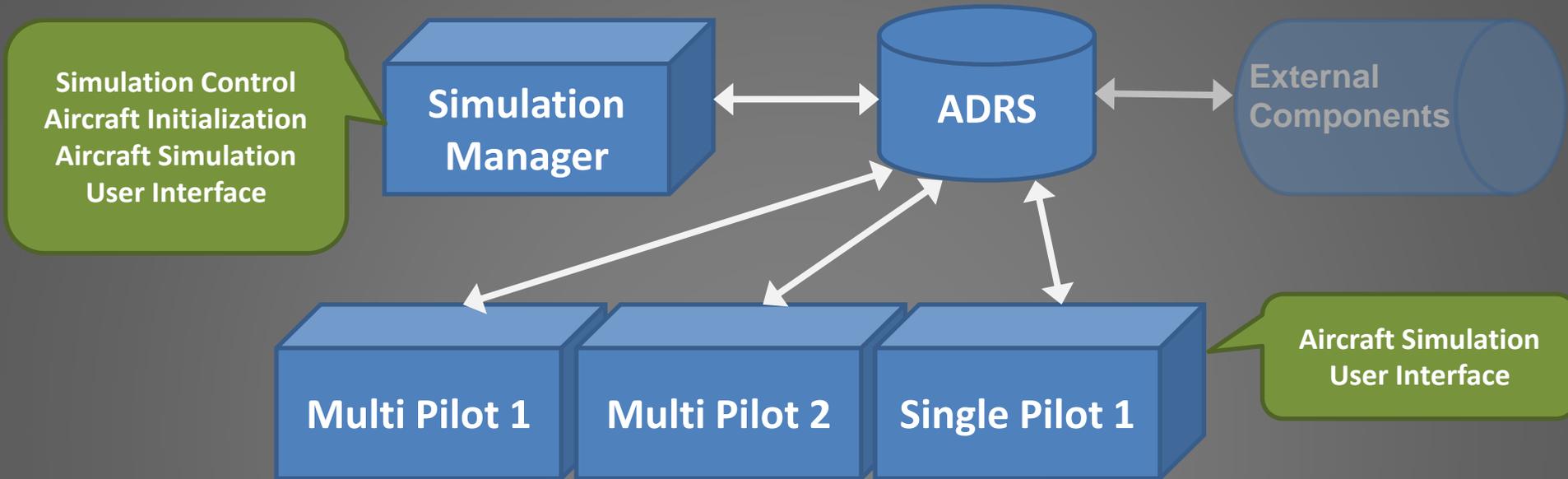
MACS Flight Deck Overview



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MACS Flight Deck Simulation Basics



- MACS architecture
 - Each MACS pilot station simulates the aircraft directly
 - The simulation “moves” with the control from pilot station to pilot station

MACS Flight Deck Simulation Basics

- Aircraft modeling parameters specified in the traffic scenario file:
 - aeroModel
 - Simple, 4DOF
 - Weight
 - costIndex
- FMS navigation (nav) database comes from adaptation files
 - Airports, jet routes, airways, waypoints, SID/STAR/approach procedures*

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MACS Flight Deck Capabilities

- All MACS aircraft are FMS equipped
- Additional flight deck equipment can be enabled through the traffic scenario file
 - ADS-B equipage
 - CPDLC equipage
 - RTA equipage
 - ASAS equipage
- Wind information
 - Constant winds at altitude
 - Rapid Update Cycle (RUC) wind files
 - Can be different from actual winds and ATC winds

MACS Flight Deck Capabilities

- Path/Terminators
 - MACS uses Track to a Fix (TF) leg segment types
- Fixes
 - MACS uses Fly-by Fixes
- Crossing Restrictions
 - MACS uses only AT restrictions
- Holding functions
- Onboard Conflict Detection
- Data Comm
 - FANS-like CPDLC interface
 - Uplink and Downlink
- Integration with Cockpit Display of Traffic Information (CDTI)

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Human-Automation Cooperation

- MACS includes agent/automation support options to help with the pseudo pilot task
 - Prompts to alert the pseudo pilot of needed action
 - Location: Windows -> Setup Panels -> Event Control
 - Automated modes that can take ownership of certain tasks
 - Auto Speed Brakes
 - Auto Landing Gear
 - Auto Flaps
 - Auto Execute Route Mods
 - Auto Altitude Control
 - Auto Processing

Radio Check In	
Radio Request for Lower	
Lower Mcp Altitude	
End of Route	
Free Flight/ATC Transition	
Entering Controlled Airspace	
Heading Probes	
Altitude Probes	
Speed Probes	
EDA Turn Back	
EDA Descent Location	
Frequency Change	
Datalink Message	
Potential Conflict	
Update Rta	
Approach	

Human-Automation Cooperation

- Auto Altitude Control
 - Automatically lowers or raises Mode Control Panel (MCP) altitude target values
 - Requires VNAV
 - Can create a need for good pseudo pilot training
- Auto Processing
 - Automatically processes Data Comm messages received on the flight deck
 - Most received uplinks can be processed automatically
 - Processing occurs within a user-definable delay range
 - Independent control for the various messages

Human-Automation Cooperation

Location: Windows -> Setup Panels -> Flight Deck Setup -> CPDLC Uplink tab

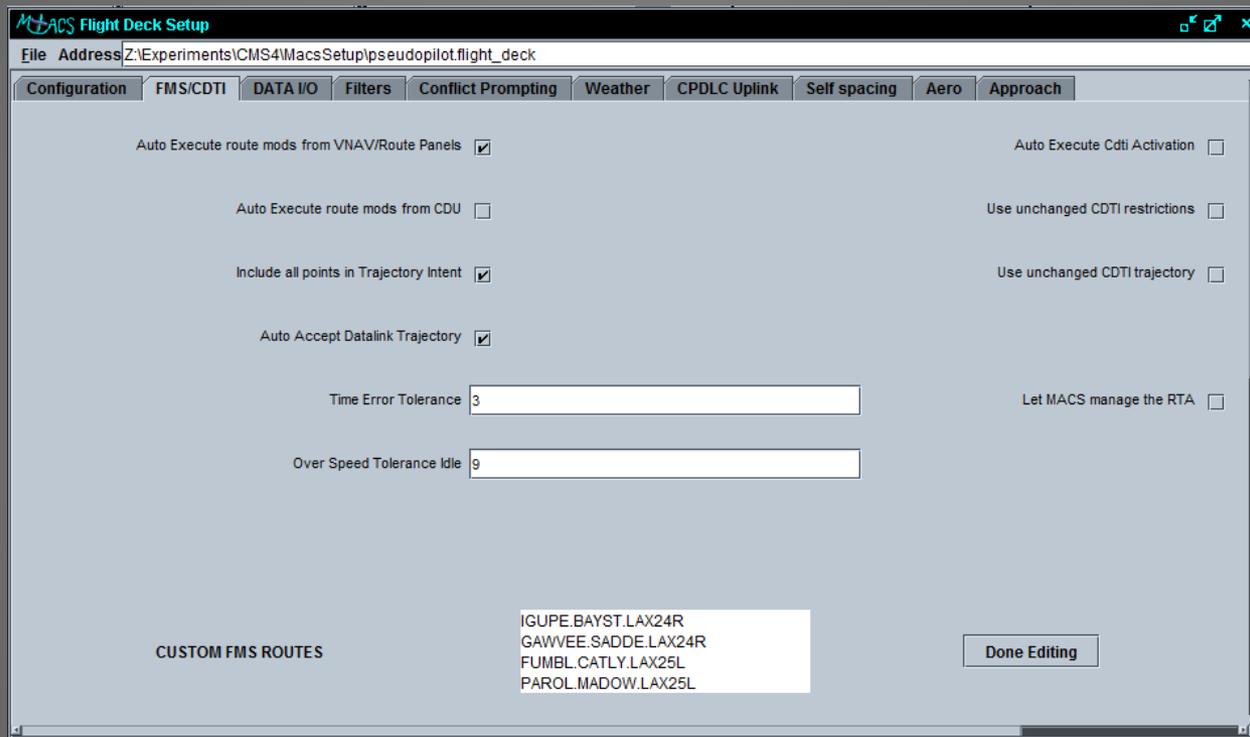
Auto Execute RTA msgs <input checked="" type="checkbox"/>	RTA Time Delay (secs) Min <input type="text" value="8"/>	Max <input type="text" value="10"/>
Auto Execute Frequency Change msgs <input checked="" type="checkbox"/>	Frequency Change Time Delay (secs) Min <input type="text" value="5"/>	Max <input type="text" value="6"/>
Auto Execute Speed msgs <input checked="" type="checkbox"/>	Speed Time Delay (secs) Min <input type="text" value="5"/>	Max <input type="text" value="6"/>
Auto Execute Altitude msgs <input checked="" type="checkbox"/>	Altitude Time Delay (secs) Min <input type="text" value="5"/>	Max <input type="text" value="6"/>
Auto Execute Route Modification msgs <input checked="" type="checkbox"/>	Route Time Delay (secs) Min <input type="text" value="5"/>	Max <input type="text" value="6"/>
Auto Execute Self-Spacing msgs <input checked="" type="checkbox"/>	Self-Spacing Time Delay (secs) Min <input type="text" value="8"/>	Max <input type="text" value="10"/>
Auto Execute Flight Rule (AFR/MFR/IFR/VFR) msgs <input checked="" type="checkbox"/>	Flight Rule Time Delay (secs) Min <input type="text" value="5"/>	Max <input type="text" value="6"/>
Auto Speak Auto Text Message <input checked="" type="checkbox"/>	Audio text Time Delay (secs) Min <input type="text" value="2"/>	Max <input type="text" value="4"/>
Auto Execute Audio Text Command <input checked="" type="checkbox"/>		
Auto exec no older than (sec) <input type="text" value="120"/>		

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Other Flight Deck Options

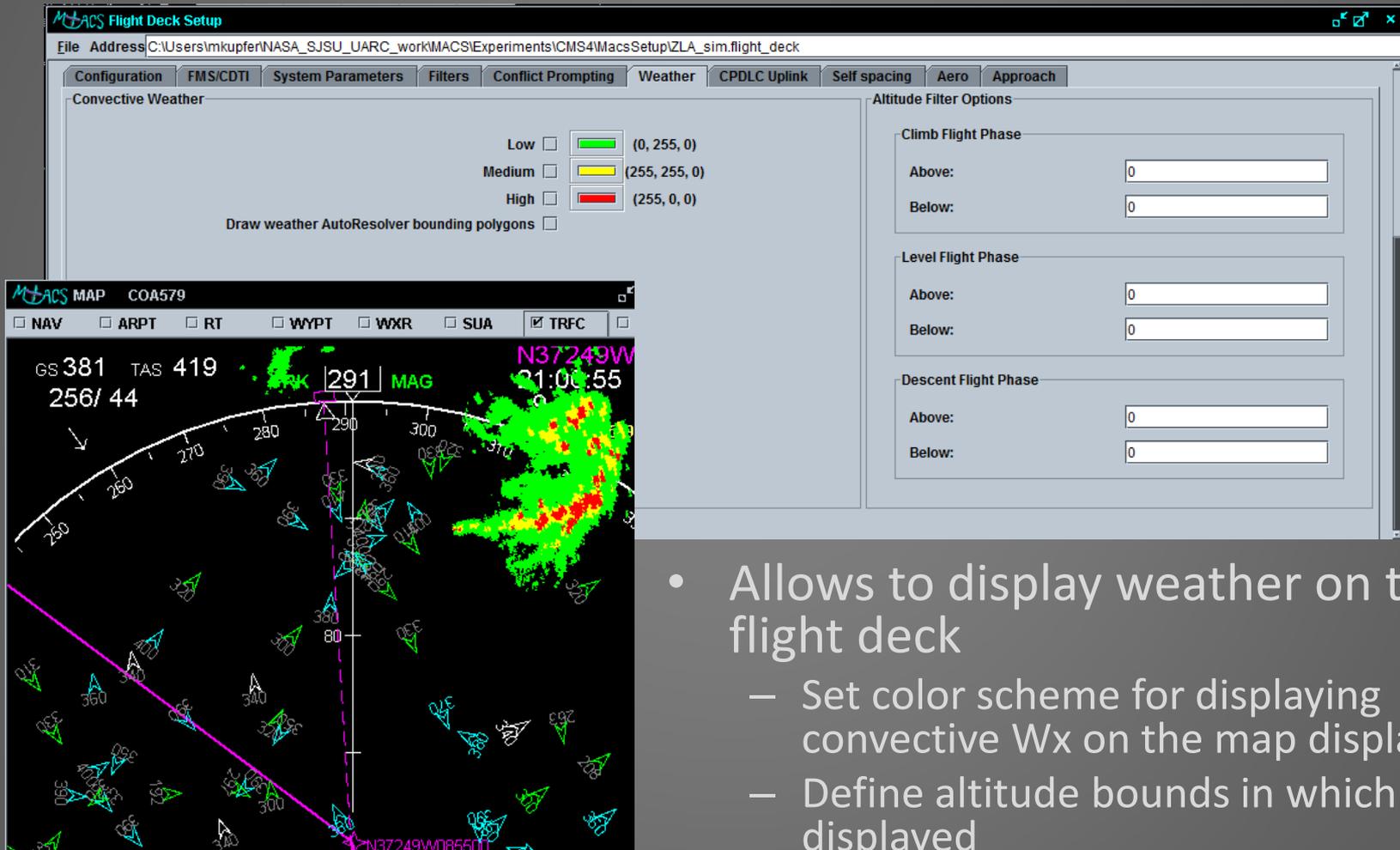
Location: Windows -> Setup Panels -> Flight Deck Setup
-> FMS/CDTI tab



- Controls auto execute of route modifications
- Enter ATC procedure names to generate custom FMS routes

Other Flight Deck Options

-> Weather tab



The image displays the MACS Flight Deck Setup application window. The 'Weather' tab is selected, showing options for 'Convective Weather' and 'Altitude Filter Options'. The 'Convective Weather' section includes color scheme settings for Low (green), Medium (yellow), and High (red) intensity, with corresponding hex codes and RGB values. The 'Altitude Filter Options' section includes input fields for 'Above' and 'Below' altitudes for Climb, Level, and Descent flight phases. Below the setup window, a flight deck map is shown with various weather data overlays, including a color-coded convective weather map and a traffic display with aircraft icons and callouts.

- Allows to display weather on the flight deck
 - Set color scheme for displaying convective Wx on the map display
 - Define altitude bounds in which Wx is displayed

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Pilot Workstation Configuration

- How are aircraft distributed across multiple pilot workstations?

- A team effort

- Sim manager
- All other connected pilot workstations
- If one crashes, the others can continue on

- Critical piece of information: the control responsibilities (the “identity,” or ownership rule) of each pilot workstation

- Specified via pilot configuration files (*.cfg) in the MacsDatabase\config\ directory

```
NAME          zid_80
|
RULES         DISPLAY
sector        all
active        yes
playback      no
source        macs
flights       all
status        all
callsign      all
cdti          yes
END_RULES

RULES         CONTROL
sector        ZID_80
active        yes
playback      no
source        pas
source        macs
flights       all
status        all
callsign      all
cdti          yes
END_RULES

# SECTION 3:
RULES         EXCEPTION
END_RULES
```

Pilot Workstation Configuration

- How are aircraft distributed across multiple pilot workstations?

- Important configs:

- Plan_b (the simulation manager)
 - Owns all aircraft not owned by anyone else
- View
 - Does not own any aircraft until manually attaches to a single aircraft
- [name]
 - Usually a sector# or a combination of multiple sectors
 - Sector number specified is known internally to MACS as the AC sector number
 - » Specified at sim start in the traffic scenario file, and continuously updated as aircraft transit the airspace
 - Can also be defined by flight rules (free flight) or individual call sign

```
NAME          zid_80
|
RULES         DISPLAY
sector        all
active        yes
playback      no
source        macs
flights       all
status        all
callsign      all
cdti          yes
END_RULES

RULES         CONTROL
sector        ZID_80
active        yes
playback      no
source        pas
source        macs
flights       all
status        all
callsign      all
cdti          yes
END_RULES

# SECTION 3:
RULES         EXCEPTION
END_RULES
```

Pilot Workstation Configuration

- How are aircraft distributed across multiple pilot workstations?
 - At sim start:
 - Simulation manager reads traffic scenario file and initializes trajectories of all aircraft (target generation)
 - ADRS looks for connected pilot workstations, and distributes aircraft matching the “identity” (ownership rules) of any connected pilot workstation
 - An attempt by a view pilot workstation to attach to an aircraft takes that aircraft from the sim manager
 - This action transfers the full task of simulating the aircraft to the respective pilot workstation

Pilot Workstation Configuration

- How are aircraft distributed across multiple pilot workstations?

– ATC clearance: “SWA113 contact center at 121.82”

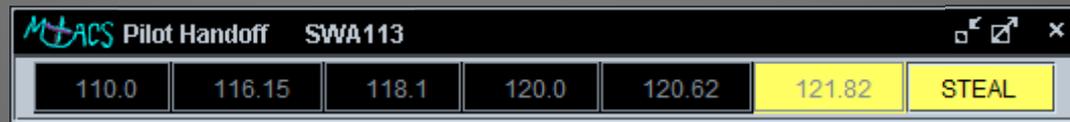
- In MACS, sector frequencies are mapped to sector numbers

– Sector_frequency_table (located in the airspace’s custom\ directory)

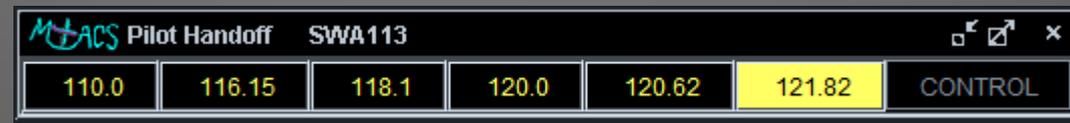
```
#2011.02.02 - This file specifies available handoff defaults and frequencies
#
default 110.00
trashcan 120.00

ZID_80 120.62
ZID_81 121.82
```

- “SWA113 switching to 121.82, good day”



- “Center, SWA113 checking in...”



Outline

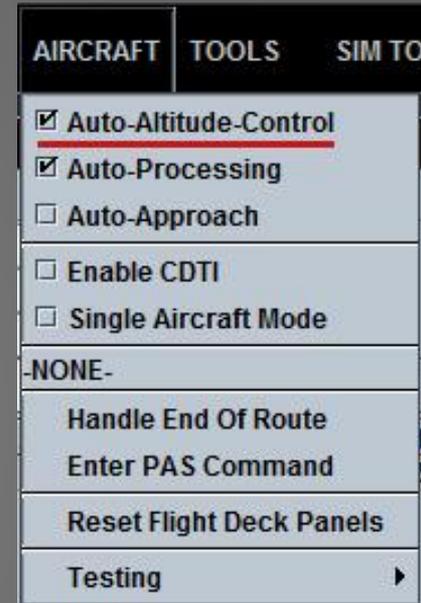
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Troubleshooting

- “Where did I go wrong?”
- Aircraft doesn't land?
 - “Descent for landing” in FMS route panel checked?
 - In SPD SEL? Needs to be in VNAV speed.
 - Aircraft too fast?
 - In FLCH? Needs to be in VNAV.
 - Aircraft too high?
 - Database's runway altitude correct?

Troubleshooting

- Context = why aren't my aircraft climbing/descending?
- Auto altitude control
 - Open loop simulations
 - Scenario development
 - ...



- Example: auto descent into TRACON

(FMS computes TOD, initialize descent once at this point)

- Auto: check Auto-Altitude-Control in Aircraft menu
- Alternatively, manual control: check precision Descent (and Descent via Transition and Descend for Landing) in the FMS Route Panel

Troubleshooting

- It appears that none of my pilot stations own aircraft234!
 - Multiple Simulation Manager (plan_b) stations
 - This can cause lots of other problems
 - Multiple instances of MACS running on the same machine
 - Verify the config files loaded by all your pilot stations

Troubleshooting

- The route loaded into my aircraft's FMS doesn't look right...
 - Verify the spelling and syntax of the route in your scenario file
 - Verify the fms_procedures file you're using is set up properly and includes the restrictions you want
 - Verify waypoints along a route are not too close together

Troubleshooting

- Help, my pseudo pilots are overloaded!
 - Use two people to staff busy pseudo pilot stations
 - E.g., lots of a/c, high frequency of clearances, vectoring in a voice environment
 - Suggested strategy: voice communication – computer interaction split

Troubleshooting

- Why does an aircraft shows up in my control list that shouldn't be here? It's flying in a completely different area than all the other planes I own...
 - Other pilot shipped it to the wrong frequency?
 - Happens in real world, too, let the controllers figure it out.
 - The pseudo pilot can also steal the aircraft

Questions?

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- Michael Kupfer - michael.kupfer@nasa.gov, (650)-604-4624

Aircraft Simulation and Flight Deck Displays

- Full flight Simulator
- Selectable Dynamics Model (Motion Predictor, 4DOF/PAS-Aero, ...)
- Flight deck for external target generator
- Performance Models for the majority of current aircraft types
- Selectable Equipage
- Glass cockpit displays
- Full FMS capabilities with RTA (Also used in Standalone mode)
- ASAS spacing and merging logic
- Conflict detection logic for (airborne self-separation)
- FANS – style CPDLC interface
- Interface to advanced Cockpit Display of Traffic Information
- Automatic processing of selected data link messages with predefined delays
- Agent support for pseudo pilots (reminders or automation)

Troubleshooting

- Enter ATC route options (go-around)
 - Prepare flight deck to execute go-arounds by entering go-around atc procedure names
 - Don't confuse with fms_procedures: MACS matches the waypoints of the respective go-around atc_procedure with the fms_procedures
 - Semicolon separated!

MACS Flight Deck Simulation Basics

- Aircraft lists
 - ALL
 - ACTIVE
 - INACTIVE
 - CTRL
 - VIEW
 - TODO
 - DONE
- How fms_procedures file works...